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STUDIES IN RETARDATION

AS GIVEN IN THE FATIGUE PHENOMENA OF THE TAPPING TEST.

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I. RETARDATION AND THE CURVE OF WORK

The experimental problems presented by this striking mental symptom are important and numerous. Definition adds little to what is implied in the term itself; in its pure state it is simply *a loss of the promptness of response to the given situation*. It does not necessarily carry with it any mental confusion; thus a long interval may elapse between a question and its answer, but when the answer does occur it may imply as perfect comprehension and insight as would be expected in the normal state. Motor reactions are delayed, ineffective, and give a superficial appearance of extreme difficulty and (usually) hesitation.

While extremely similar conditions occasionally appear in other psychoses, retardation is *par excellence* a symptom of manic-depressive depression, the depressed phase of the Kraepelinian manic-depressive insanity. In this disorder it is perhaps the most familiar objective symptom, and it is only in its relation to this disorder that it need be considered here. Its physiological correlate is unknown, and of its intimate psychological nature much still remains to be cleared up, especially in the analysis of its factors, and the relative part which sensory, associative and motor elements may play in the ultimate product.

The present study proceeds mainly along the lines first suggested by Hoch. Clinical observation indicates that under the continued activities of the waking day the characteristics of the retarded state in circular depressions tend to become less profound, and that these activities effect a change in such

cases far more marked in character and amount than in the case with normal individuals. From this fact the inference is suggested, that if we could standardize the activities of such cases over a certain period, introducing controllable and measurable forms of activity, we should find in the measures thus obtained characteristic deviations from the normal corresponding to the clinically observable changes in the patient's condition. One would thus be afforded at once a quantitative measure for the extent of retardation, as well as a means of detecting its presence and changes in its amount so slight as to escape ordinary clinical observation.

The experimental problem then, is a study of the work curve in retarded individuals, but the various psychological tests that can be applied to the problem of the work-curve are not equally well suited to the purposes in hand. The measures most frequently employed in problems of this nature are those of the ergograph and the addition test. No one will dispute the value of the mass of data which Kraepelin's pupils have accumulated about these measures, which the present studies largely confirm at their points of contact. Certain advantages may perhaps be urged for the present method. The ergograph is strong where the addition test is weak, namely in the objectivity of the results, simplicity of procedure, the control of co-operation, and in the amount of time consumed in the experiment. The addition test is strong where the ergograph is weak, namely in the simplicity of the apparatus, and the detail and minuteness with which it is possible to trace such factors as warming up, reflex inhibition and the *Antriebe*. The tapping test, however, while retaining the objectivity and precision of the ergograph, sacrifices none of the detail and minuteness possessed by the addition test under sufficiently refined conditions of measurement. In the matter of its demands upon co-operation, the tapping test is easily the superior of both. Further, there is probably no motor measure which is less dependent upon muscular factors.

The method and conduct of the experiments is identical with that described in a previous paper.¹ Each individual curve consists of 30'' of continued tapping, evaluated according to number of taps executed in each 5'' interval during the 30'' period. Between each of two 30'' periods of tapping there is a 2' 30'' pause. Six successive 5'' intervals thus constitute a *series* (or individual curve), and five 30'' series with one hand form a *record*. The two records of right and left hand constitute the single *experiment*. There are given the results of two experi-

¹ Normal Performance in the Tapping Test, *American Journal of Psychology*, XIX, 1908, pp. 437-83.

TABLE I

Number of taps executed in 30" periods. In each experiment the subject executes five 30" series with one hand, then five series with the other hand. The second experiment follows one week upon the first.

First Experiment (Right Hand Preceding)

Rt. Hd.

Depressions. Case	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Average	Average of 10 Normal Subjects
1st Series,	160	185	203	160	151	182	242	154	72	174	202	173	168.3	192
2nd "	164	183	200	165	139	171	225	160	73	164	209	168	164.4	190
3rd "	145	188	209	172	140	179	232	162	75	174	181	173	167.6	194
4th "	153	191	208	175	138	190	236	165	76	191	187	171	172.3	199
5th "	144	188	218	177	137	198	239	164	85	189	204	150	173.9	199
Av.	153.2	187.0	207.6	169.8	141.0	184.0	234.8	161.0	76.2	178.4	196.6	167.0	169.3	195

Lft. Hd.

Depressions. Case	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Average	Average of 10 Normal Subjects
1st Series,	148	167	196	179	143	171	213	148	69	192	187	162	162.6	173
2nd "	136	166	196	170	140	156	210	154	80	181	190	149	158.9	172
3rd "	141	167	196	177	140	155	215	152	83	184	177	154	161.0	174
4th "	135	175	192	180	138	158	215	153	79	190	173	151	161.5	172
5th "	149	167	206	166	149	148	215	153	78	190	168	152	162.1	173
Av.	141.8	168.4	197.2	174.4	142.0	157.6	213.6	151.6	77.8	187.4	179.0	153.6	161.2	173.0

TABLE I (Cont.)
Second Experiment (Left Hand Preceding)
Rt. Hd.

Depressions. Case	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Average	Average of 10 Normal Subjects
1st Series,	178	197	188	128	144	186	238	156	89	168	202	147	167.2	189
2nd "	188	188	194	131	134	191	234	155	89	179	203	158	168.3	191
3rd "	188	188	198	137	147	195	234	159	93	170	204	144	170.9	195
4th "	184	188	207	139	152	200	233	160	84	185	203	155	173.2	197
5th "	195	191	212	146	150	198	250	156	91	175	200	149	176.4	196
Av.	186.6	190.4	199.8	136.2	145.4	194.0	237.8	157.2	89.2	175.4	202.4	150.6	171.2	194

Lft. Hd.

Depressions. Case	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Average	Average of 10 Normal Subjects
1st Series,	152	170	191	144	143	152	206	141	87	177	181	146	156.3	178
2nd "	137	169	189	135	143	151	193	135	92	164	185	137	151.0	175
3rd "	154	170	187	162	147	159	196	140	88	171	191	129	157.4	177
4th "	161	171	193	143	149	164	202	144	85	160	178	165	157.2	176
5th "	152	168	202	144	142	170	211	145	85	161	185	160	158.0	175
Av.	151.2	169.6	192.4	144.6	144.8	159.2	201.6	141.0	87.4	166.6	184.0	147.4	155.8	176

TABLE II

Average number of taps in each 5" interval of the five thirty second series with either hand in each experiment. Fatigue is shown in the decrease in the number of taps as the later intervals are reached; "reversal" or interserial warming up in the failure of the successive intervals to regularly decrease.

First Experiment (Right Hand Preceding)

Rt. Hd.

Depressions. Case	I	II	III	IV	V	VI	VII	VIII.	IX	X	XI	XII	Average	Average of 10 Normal Subjects
1st interval, 0"-5"	24.0	31.0	38.0	29.4	22.8	30.2	41.4	27.6	12.8	30.2	32.0	27.2	28.7	35.3
2nd " 5"-10"	24.8	32.8	36.0	29.4	23.8	31.6	41.2	27.0	12.8	31.0	34.0	28.2	29.0	33.5
3rd " 10"-15"	25.8	32.0	34.2	28.8	23.2	31.0	39.0	26.6	12.2	30.2	32.6	27.8	28.3	32.3
4th " 15"-20"	26.8	30.6	34.2	28.6	24.0	30.6	39.0	27.0	12.8	29.0	34.2	28.0	28.2	31.5
5th " 20"-25"	25.8	30.8	32.8	27.4	23.6	29.8	38.0	26.4	12.8	29.2	31.8	28.2	27.7	31.0
6th " 25"-30"	26.0	29.8	32.4	26.2	23.6	30.8	36.2	26.4	12.8	28.8	32.0	27.6	27.3	30.7

Index of fatigue <i>f</i>	1.08	1.01	.89	.96	1.04	1.02	.93	.97	.99	.99	1.03	1.03	.98	.90
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(*f* is the average of the last five intervals divided by the first.) With reference to this measure, Cf. *American Journal of Psychology*, XIX, 1908, pp. 467 *et seq.*

Lft. Hd.

Depressions. Case	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Average	Average of 10 Normal Subjects
1st interval, 0"-5"	23.8	29.6	36.8	32.0	23.4	28.2	38.6	26.6	12.8	33.8	31.2	24.6	28.6	32.0
2nd " 5"-10"	24.0	29.4	34.4	30.8	23.6	27.0	37.0	25.4	13.0	32.2	30.6	25.8	27.7	31.1
3rd " 10"-15"	23.8	28.8	32.8	29.8	24.0	26.0	36.0	25.2	12.8	31.4	29.0	26.0	27.1	28.7
4th " 15"-20"	23.4	27.0	30.8	28.6	24.0	26.0	35.0	25.0	13.2	30.6	29.8	25.8	26.4	28.0
5th " 20"-25"	23.8	26.6	31.2	26.8	23.2	25.6	33.4	25.2	13.0	29.8	29.6	25.2	26.9	27.3
6th " 25"-30"	23.0	27.0	31.2	26.4	23.8	24.8	33.6	24.6	13.0	29.6	28.8	26.2	25.7	26.9

f

.99

.94

.87

.89

1.01

.92

.91

.94

1.01

.91

.95

1.06

.93

.89

TABLE II (Cont.)
Second Experiment. (Left Hand Preceding)
Rt. Hd.

Depressions. Case	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Average	Average of 10 Normal Subjects
1st interval, 0'-5"	31.2	32.6	37.0	22.4	24.2	33.0	44.0	26.4	14.6	30.0	32.8	24.0	29.5	35.0
2nd "	5'-10"	32.0	34.4	22.2	24.0	33.0	41.4	26.2	14.6	30.0	33.6	24.6	29.1	33.2
3rd "	10'-15"	31.4	33.4	23.4	24.2	32.6	39.6	26.4	15.0	29.8	33.4	25.2	28.8	32.2
4th "	15'-20"	31.4	32.2	22.2	24.4	32.4	38.8	26.4	15.0	29.8	34.2	25.6	28.3	31.6
5th "	20'-25"	30.2	31.0	23.4	23.8	31.4	37.0	25.8	15.0	28.8	33.6	25.4	27.8	31.4
6th "	25'-30"	30.4	30.2	22.6	24.0	31.6	37.0	26.0	15.0	28.0	34.8	26.0	27.6	30.7
<i>f</i>	.99	.97	.88	1.02	1.00	.98	.88	.99	1.02	.98	1.03	1.06	.96	.91

Lft Hd.

Depressions. Case	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Average	Average of 10 Normal Subjects
1st interval, 0'-5"	26.0	30.0	35.0	24.6	22.8	28.2	35.2	25.2	14.0	29.8	31.4	23.2	27.1	32.3
2nd "	5'-10"	26.0	34.4	24.2	25.0	27.2	34.4	24.2	14.6	28.6	32.4	24.4	26.8	30.8
3rd "	10'-15"	25.6	28.6	32.0	24.4	26.6	34.2	23.2	14.4	28.4	30.8	24.4	27.0	29.3
4th "	15'-20"	24.8	27.6	31.2	24.4	26.4	33.2	23.0	14.6	27.6	29.6	25.2	25.7	28.3
5th "	20'-25"	24.6	27.0	30.0	23.6	25.6	32.6	22.6	14.8	26.6	30.8	25.0	25.2	28.1
6th "	25'-30"	24.2	26.8	29.8	24.4	25.2	32.0	22.8	15.0	25.6	29.0	25.2	25.0	27.5
<i>f</i>	.96	.93	.90	.98	1.07	.93	.94	.92	1.05	.92	.97	1.07	.96	.89

ments upon each of twelve subjects. *In the first experiment the right hand precedes, in the second the left hand precedes.*

The statistical aspect of the results is summed up in the accompanying tables. Table I gives the results in terms of the total number of taps in each of the five 30" series in each experiment with each hand. In this table the decreased total efficiency of the retarded records as compared to the normal average is the principal thing to note. In Table II the figures are given according to the averages of all the series for each 5" interval, in order to convey an idea of the fatigue phenomena which the series show. It will be noted that the series for the depressed subjects, while slower in rate, show very much less fatigue than does the normal average. In these two facts lie the principal deviations of the depressed subjects from the normal.

It will be observed that in the averages for the intervals (Table II) the first interval is often surpassed in rate by a later interval, which is not the case in normal subjects. To this characteristic phenomenon we shall apply the name of *reversal*. It is an *intra*-serial warming up, warming up within the individual series, as distinguished from the *inter*-serial warming up, warming up between the series, discussed at some length previously.¹ As a marked illustration of this *reversal* may be quoted the figures from Table II of Case I's right hand in the first experiment; in the first five seconds he averages 24.0 taps, in the second five 24.8 taps, in the third 25.8, in the fourth 26.8, in the fifth and sixth intervals 25.8 and 26.0. That is, there is regular "reversal" to the fourth interval, the opposite of the normal curve. Case III on the other hand shows no "reversal" at all.

The index of right handedness² shows an analogous phenomenon, to which is applied the name *transference*. In the normal individuals it was noted that the index tended to no regular fluctuations according as the right or left hand preceded. Here, however, many of the cases show a very pronounced tendency for the index to be lower (*i. e.* a relative superiority of the right hand) in the second experiment, when the right hand follows. The indices in the depressed cases are given in the table on the next page.

The indices show that in most cases the work with the preceding hand *transfers* its warming up effect to the work with the following hand.

Cases I-X are under the diagnosis of manic-depressive depression. In Case XI the depressive picture is complicated with

¹ *Am. J. Psych.*, XIX, 1908, pp. 446-47, 457-61.

² *Ibid.*, pp. 446, 454-56.

Index of Right-Handedness, (Lft. Hd. ÷ Rt. Hd.)

Case..	I	II	III	IV	V	VI	VII	VIII
First Experiment, Right Hand Preceding	.93	.90	.95	1.03	1.01	.96	.91	.98
Second Experiment, Left Hand Preceding	.81	.89	.96	1.06	.99	.82	.85	.90

Case..	IX	X	XI	XII	Average	Average of 10 Normal Subjects
First Experiment, Right Hand Preceding	1.02	1.05	.91	.92	.95	.89
Second Experiment, Left Hand Preceding	.98	.95	.93	.95	.91	.91

traumatic traits, in Case XII with psychasthenic symptoms. These two cases do not therefore present a manic-depressive picture sufficiently unequivocal to make it advisable to include them in the averages of the other ten. Their experimental correspondence with them, however, justifies their separate quotation. In addition, experiments have been made upon some thirty other pathological subjects, representing various disease groups.

To any one familiar with cases of this type, it will be scarcely necessary to say that, although presented under one and the same diagnosis they really afford very diversified clinical pictures. These individuals are in all respects much more different from one another than the ten normal subjects to whom we perforce compare them. These individual differences have naturally a great influence on the character of the results we obtain from them. Many striking peculiarities in the individual records would become much more intelligible if these differences were made clear. To do this, however, would expand the paper to more than three times its present proportions, and even so would intrude much matter in a form significant only to the clinician who could read between the lines of the histories and physicians' notes. It has seemed preferable, therefore, to dispense for the present with any detailed treatment in connection with the individual pictures, which are best presented primarily from the clinical viewpoint. It may be said at the outset, however, that no subject figures in the present data whose co-operation would not have been regarded as entirely trustworthy in a normal subject.

2. THE RESULTS AS THE PRODUCT OF RETARDATION

In gross rate there is an entirely fundamental difference in favor of the normal individuals. Taking the normal standards for right and left hands as 194 and 175, those for the depressed subjects become 170 and 159. It is thus also seen that in the depressed subjects there is rather less difference between the right and left hands than in the normal subjects. In the relationship of the five successive series to each other, the groups show no difference worth mentioning. In both normal and depressed subjects inter-serial warming up is noticed in the right hand, not in the left. As regards individual differences in the two groups, these are distinctly greater in the depressed subjects. The m. v. of the average "total efficiency" figures for the normal and depressed subjects in each experiment, as well as for the average indices of fatigue, or f 's, are as follows:

M. V. of Gross Rates					M. V. of f 's	
	R ₁	R ₂	L ₁	L ₂	R	L
Normal	14	18	14	16	.038	.030
Depressed	29	31	27	22	.043	.041

The depressed individuals, then, differ more among themselves than do the normal individuals. Since this was true also of age, and of other characters irrelevant to the depression, it is not possible to say how far this greater variability is in direct relation to the depression; to some extent, it probably is so.¹

In the average gross rate for the normal individuals, the preceding hand is the more favored; in the depressed individuals, on the contrary, it is the following hand which is the more favored. The final figures expressing this relation are as follows:

	R ₁	R ₂	L ₁	L ₂
Normal	195	194	173	176
Depressed	169	171	161	156

In R₁ and L₁ the left hand follows, in R₂ and L₂ the right hand follows. Each hand is better when it follows than when it precedes in the depressed subjects. Each hand is better when it precedes than when it follows in the normal subjects. We noted this tendency of the following hand to be the more favored in many of the depressed subjects individually, under the name of "transference"² and we now observe that this tendency is sufficient to be reflected in the averages.

¹The same observation is made by Hutt (*Ps. Arb.* V., p. 354), the women being less variable than the men. It may be noted that the left hand is here less variable than the right, as was also found in the normal group.

²*Cf.* the figures for the index of right handedness, p. 45

Finally, there is the fundamental difference between the two groups in the matter of their relative immunity to fatigue within the individual series. In considering the individual cases we meet time and time again with fatigue phenomena absolutely foreign to what has been observed in normal individuals. Not only is the f in the depressed cases abnormally high, differing from the normal f considerably beyond the limits of the probable error, but there are noted in many individual cases fundamental alterations in the shape of the fatigue curve itself. In these cases the curve of work does not begin at its maximum efficiency with gradual loss by fatigue, as in normal subjects, but there is a prolonged period through which the performance actually increases to a level above its initial efficiency. The most marked instances of this phenomenon are to be found in Cases I, IV, and XII. We have here a set of favorable influences operating on the curve of work which are sufficiently potent to more than counterbalance the fatigue losses which normally have the preponderating influence. The degree to which these influences operate naturally varies with the different subjects. In the most extreme series with Case XII the increase in rate was continual throughout the 30 seconds, and it is impossible to say how much longer the gain would have continued before fatigue overbalanced it; in Case II, on the other hand, the gain was apparent only in the right hand and then not further than the second or third interval. In other cases, as VIII and X, these favorable influences are not sufficiently strong to make the later intervals actually faster than the earlier, and their effects are seen merely in a raising of the f towards the limit 1.00, which is surpassed in such cases as XII or V.

Only with great caution, however, is an f below 1.00 to be accepted as evidence of retardation in the absence of reversals. An f above 1.00 cannot occur without reversal; but an f below 1.00 can occur either with reversal, or merely a very slow fatigue loss. This latter condition may mean, as above indicated, a true retardation, but it may be also the result of indifferent co-operation, and we usually have no evidence which. One objective criterion of co-operation we occasionally do have: if during the course of the tapping the energy directed to this work "overflows," as it were, into other motor pathways, and the subject shows generalized body movements in addition to the tapping, co-operation can ordinarily be accepted without further question; but entirely trustworthy co-operation occurs without this being observed at all. Beyond an unmistakable lowering of gross rate, the only justifiable criteria of retardation in these experiments are reversal and transference. These are essentially unaffected by differences in co-operativeness.

Either reversal, transference, or both, is observed in all the twelve preceding subjects save Case III. This case gave the appearance of some retardation; there is certainly more ground for surprise at not finding evidences of it in the results than there would have been at finding them. It remains exceptional among the present observations.

Turning attention now to the more general aspect of the results as given in the above special and particular manifestations, it is evident that the common factors in all the anomalies noted in the depressed records are a lowered gross efficiency of performance and an increased responsiveness to the favorable influences operative upon the curve of work. The lowered efficiency of performance is manifested in the decreased gross rate, roughly to 89% of the normal. The increased responsiveness to favorable influences operative upon the curve of work is manifested in the greater efficiency of the following hand as such (transference) and in the phenomenon of intra-serial warming up (reversal).

The general slowing up of all responses which forms so prominent a feature in a large number of depressions, is described under the generic term of *retardation*; and in the present results we are afforded a quantitative index of certain phases of this symptom. Retardation is to be regarded as the most important factor in the lowered gross rates in these cases, nor should we in its absence observe the increased responsiveness to favorable influences which plays so great a part in the present experiments.

With regard to the exaggerated transference effects as a phase of the retardation may be cited the observations of Hoch.¹ These experiments were made on the ergograph, with exceptionally careful technique, and consist each of three "exhaustion" curves executed at intervals of 15 minutes. For comparison with the present experiments, therefore, each curve corresponds best with a record with one hand and the 15 minutes to the 2' 30" pause between the hands; save that 15' was known to be the *günstige Pause* for the ergograph, while we do not know the relation of the 2' 30" pause to the tapping test.

The retardation was considered to be given in the fact that the depressed cases showed an increase in the number of times the weight was lifted (*Hubzahl*) throughout the three curves on a single day, though the *Hubzahl* shows no practice increase from day to day. The increased efficiency of performance of the following curves over the preceding ones is entirely parallel to the more favorable position of the following hand noted

¹On Certain Studies with the Ergograph. *Journal Nerv. Ment. Disease*, XXVIII (1901), pp. 620-628.

in the present subjects. In Hoch's terminology, we may speak of the preceding hand overcoming certain "resistances," which brings about a greater efficiency in the later series with the following hand. Under this interpretation the "resistances" overcome must be of a general nature since the one hand benefits from the work of the other. The only difficulty in the analogy between the two experiments is, why do not the earlier series bring about greater efficiency in the later series of the same hand, *i. e.*, an exaggeration of inter-serial warming-up? We do not obtain this in any significant degree save in certain other experiments with Cases IV and XII, where there is exceptional overcoming of retardation; in this respect the normal and depressed subjects are practically on an equal footing. Still, when the fundamental differences in the methods are taken into account, this discrepancy cannot be considered a very formidable one. The same general process is at work in both sets of results.

The phenomenon of intra-serial warming up, *i. e.*, the gain in the later intervals over the earlier (reversal), is more closely paralleled in the experiments of Hutt.¹ The object of inquiry in these experiments is practically identical with the present, Hutt making use of the addition test. The depressions are 15 in number, 5 men and 10 women. The properties of the addition test under these experimental conditions in normal subjects are fairly well known. When the ten minutes of work are continuous the number of additions performed in the second 5' is regularly less than that of the first 5'. If, on the other hand, a 5' pause is inserted between the two halves of the experiment, the second 5' is regularly better than the first 5'. Hutt's depressions, like the present ones, showed a lowered efficiency of performance; but whether a pause was inserted or not, the second 5' showed an unequivocal tendency to be better than the first 5'. The improvement in the second 5' without the pause corresponds to the improvement in the later intervals over the earlier (intra-serial warming up, reversal) noted in the present experiments. With regard to the days with the pause, the situation is complicated. Normal individuals gain in the second 5' with the pause, but, according to the normal results given by Hutt from the researches of Plaut and of Rehm (p. 356) *they do not gain so much as the depressed individuals when these latter gain at all*. With considerable frequency occur depressed individuals who lose after the pause, and statistically there is very wide variation in Hutt's Table I, Column 3, (p. 355), between those who gain after the pause and those who lose. All loss after the pause is abnormal, and those

¹Rechenversuche bei Manisch-Depressiven. *Ps. Arb.* V, 3 (1908), pp. 338-370.

who gain after the pause very frequently gain more than the normal. This abnormal gain after the pause is another aspect of the abnormal gain from 15' rest to 15' rest noted in the ergographic experiments of Hoch, and probably also of the hand to hand "transference" gains in the present experiments. Those who lose after the pause suggest the "more pronounced" case mentioned by Hoch (Ps. Bull. I, 255), in which both "warming up" and practice were absent.

For their behavior with respect to the pause, Hutt divides his material into four groups. (a) Those who lose without and gain with the pause. This is the normal relationship, but quantitatively, *the loss in the depressions is less, and the gain is more*. (b) Those who gain with and without the pause (by far the most numerous). (c) Those who gain without and lose with the pause. (d) Those who lose both with and without the pause. Though small, these last two groups are of some interest from the interpretational point of view. Be the experimental approach the ergograph, addition test, or tapping test, the interpretation "overcoming of initial resistances through the warming up effects of continued effort" will cover all cases in which the work curve of depressed subjects (a) loses less than the normal loses, (b) gains more than the normal gains, (c) gains when the normal loses. The remaining cases are those who both gain when the normal should lose (without the pause), and lose when the normal should gain (with the pause), and those who lose in both instances. For the loss after the pause Hutt (p. 360) suggests that the cessation from the effort for a sufficiently long period allows the retardation to again establish itself. (*Cf.* also Hoch, p. 624.) The resistances, now added to the fatigue induced by the previous 5', suffice to make the second 5' poorer than the first. There are only two cases who, losing with the pause, also lose without it. In neither of these cases does Hutt lay any special stress on the loss without the pause, attributing it to chance *Antriebswirkungen* in the first 5'; but this interpretation cannot be well reconciled with the loss after the pause, for which he invokes in the second case "rasches Schwinden der Arbeitsbereitschaft durch *Wiederauftreten*¹ der Hemmungen in der Pause." *Hemmungen* cannot *wieder auftreten* which have not been already *beseitigt*, and the experimental records show no evidence of any *Beseitigung*. Rather do we have here a complete failure of response to any "warming up" influences. "In der Tat," Hutt continues, "bot auch dieser Fall eine sehr stark ausgeprägte Denk- und Willenshemmung dar."²

¹The italics are mine. F. L. W.

²*Cf.* p. 53.

But whatever may be the correct interpretation of such exceptional cases, the fact that the same general result is reached in these independent investigations, by as many different modes of experimental approach, points strongly in favor of the similar interpretations suggested in each case. It is interesting to note how closely the phraseology of Hutt parallels that of Hoch, of whose work Hutt seems to have been unaware. He writes, "Wie uns scheint, vermag hier die klinische Erfahrung einen Fingerzeig zu geben, in welcher Richtung etwa die Erklärung für das abweichende Verhalten unserer Kranken zu suchen sei. Die alltägliche Betrachtung lehrt uns, dass sie vielfach Hemmungen unterliegen, die durch eine längere Beschäftigung mit ihnen allmählich an Stärke abnehmen. Gilt dies zunächst für die depressiven Kranken, so tritt uns bei den manischen eine ganz ähnliche Erscheinung in der Erfahrung entgegen, dass sich bei ihnen die Erregung durch dauernde motorische Betätigung in sehr auffallender Weise zu steigern pflegt. Uebertragen wir diese Gesichtspunkte auf die hier vorliegenden Versuche, so würde uns ihr Ausfall unter der Voraussetzung verständlich erscheinen, dass durch die fortlaufende Arbeit selbst Hemmungen beseitigt werden, die den Ablauf der geistigen Arbeit zunächst verlangsamt haben. Daraus würde sich die geringe Durchschnittsleistung unserer Kranken in den ersten 5 Minuten ihrer Arbeitszeit und das Anwachsen der Leistung in den zweiten 5 Minuten an den pausenlosen Tagen befriedigend erklären. Die bei Gesunden hier überwiegenden Ermüdungserscheinungen würden bei ihnen überreichlich wieder ausgeglichen werden, dass sie im Laufe der Arbeit Hemmungen überwinden, die ursprünglich die Leistungsfähigkeit weit unter die Norm herabdrückten."

So far as the depressions are concerned¹, these remarks apply equally well to the above mentioned experiments of Hoch and those of the writer. The final indication seems to be, that the curve of continued work shows in retarded patients an abnormality characterized by a low efficiency of initial performance, which the overcoming of the retardation through the activity of the work either (a) raises to a higher level, or (b) maintains at or near the initial level longer than would normally be the case.

3. THE METHOD AS A MEASURE OF RETARDATION

Inasmuch as the alterations in the work curve observed in

¹ Hutt's manic cases (8 in number) are distributed among the first three groups of his depressions, though he does not give them quite the same interpretation. In the tapping test the manic performance is the absolute antithesis of the depressed. This apparent contradiction will be discussed under a separate treatment of the manic cases.

retarded individuals are of the same general nature independently of the class of tests we employ, the most reliable results are probably to be expected from the test which is intrinsically the most accurate psychological measure. The advantages of the tapping test in this respect the writer has already endeavored to point out. We have now to inquire to what extent the alterations in the fatigue curve may afford a quantitative measure of individual or personal differences in the extent of retardation. It is necessary to consider two aspects of the curves; first the amount of lowering of gross efficiency; second, the transference and resistance to fatigue, or intra-serial warming up. The first factor would indicate the absolute amount of retardation, the second, how far this retardation tended to be overcome. For comparisons between different individuals, the method is very limited indeed. It is difficult to say whether A is more retarded than B from a comparison of their gross rates; the fundamental individual differences are too great. (*Cf.* Hutt, p. 353.) Nor does the amount of intra-serial warming up or "reversal" afford a reliable index of whether one individual is more retarded than another, *e. g.*, these phenomena were most marked in Subject XII, in whom retardation was hardly, if at all, clinically evident.

A much more practical question is whether the method affords a means of measuring changes in the degree of retardation and thus reflecting changes in the condition of the same individual. Its behavior in this respect is a much more constant one. Increased gross rate regularly accompanies improvement in condition, decreased gross rate a drop in the condition. It is interesting to note that it does this with rather more regularity than seems to be the case in normal individuals. Through the thirty experiments reported in a previous paper,¹ the writer could detect no relationship between gross rate and subjective condition, and this result was entirely confirmed by unsystematic inquiries made in the case of Subject II. Among the present subjects, in Case III alone is the clinical change opposite to that of the gross rate. In Case VII, the gross rate does not reflect a slight clinical change. In Case V there is neither clinical nor experimental change. Changes in gross rate occur in the absence of *positive* clinical observations in Cases I, VI and XI. More careful and extended observations on Cases VIII and XII as well as Cases II, IV, IX and X reflect a correspondence with entire clearness.

Knowing the gross rate of a depressed subject in the normal state, the performance in the depressed condition should afford

¹ *Loc. cit.*, pp. 480-1.

an indication of the extent of retardation as well as its presence, but as these experiments are made we do not know the normal rate. Only as the rate actually found changes with the patient's condition is any evidence of retardation found in the rate alone. Owing to this limitation, we can be much surer of the presence of retardation when we find the characteristic alteration in the shape of fatigue curve (intra-serial warming up, reversals and transference) brought about by the overcoming of its resistances. The relation which is indicated between the gross rate and the warming up phenomena is complex, but consistent. Generally speaking, the lowered gross rate indicates a condition of retardation. The warming up phenomena indicate the extent to which the continued activity of the test tends to overcome this retardation, *i. e.*, the responsiveness of the individual to warming up influences. We shall not, of course, expect abnormal warming up phenomena in the absence of retardation; the hypothesis that resistances are overcome postulates resistances present to be overcome. The important thing to remember is that they may be present without being overcome; and that we may have considerable retardation without the slightest trace of warming up effects. Indeed, there is evidence that these cases, in which we may obtain a fatigue curve quite resembling the normal in form, may present rather the profounder degree of retardation. A slight retardation then, will show a somewhat lowered gross rate and decreased susceptibility to fatigue, with reversal perhaps in the second interval (*Cf.* Case II); when the retardation becomes deeper, the gross rate is further lowered, and the immunity to fatigue is more marked, with reversals in the later, even up to the final intervals; with yet more profound retardation the warming up effect fails, and we obtain in the later intervals a loss approaching the normal. Hutt's Figure III probably illustrates these phases better than do the here quoted results. Considering of course, only the results without the pause, we obtain first the three depressions who lose during the second 5', just as normal individuals would do (Group a), then a group of eight depressions gradually gaining more and more during the second 5' (Group b), then another group of three depressions who, while they still gain during the second 5', yet lose with the pause, showing a more profound degree of retardation than the preceding, (Group c), and finally two depressions (3 records) who again lose during the second 5', (Group d), just as did the group (a) at the other extreme. The present observations, when considered in connection with the clinical data, are entirely confirmatory of Hutt's findings on this point, and certain individual cases, notably IV and XII, illustrate the matter rather more strikingly, owing to the greater

precision of the method. Such interpretations, however, have no relation to the comparison of the depth of depression in different individuals, applying only to the different conditions of the same individual.

4. RETARDATION AND DEPRESSION

With this result the strictly experimental portion of our inquiry ends, but in closing, a few words may be devoted to the psychological relations of retardation to the general symptoms of the manic-depressive disorders that seem to maintain the best correspondence with the observed facts of clinical experience. We shall make a grave mistake if we start out with the idea of finding any single formula that will express the relationship of depression and retardation in all manic-depressive states. We shall have to distinguish at least three forms in which retardation may occur, as follows:

1. Cases in which the depression seems to be the fundamental thing and such retardation as is clinically observed can be amply accounted for as secondary to the depression. Case VIII is an excellent example of this type.

2. Cases in which the retardation is fundamental, even to the extent of swallowing up the depression. The present observations contain no really classical case of this type; its best representatives are probably Cases IV and VI.

3. Cases in which the retardation is independent of the emotional condition, including other conditions than manic-depressive insanity.

In the first group we have a class of cases that may be most instructively compared with the reactions in our own depressed moods. Here, as there, the essential of the state is its emotional tone. Of the physiology of the emotions we know little enough, and still less of their pathology; but that emotional states are the product of physiological adjustments of some sort, and do not exist in the absence of these adjustments, few will be found to deny. Every physiological adjustment of the organism carries with it its own essential emotional tone. Such readjustments are, of course, brought about in various ways. In the emotional sphere, it is usually central causes which are the immediately determining factors, though the influence of organic processes, such as digestion, is, of course, far from negligible. The same physiological adjustment as is brought about through a severe mental shock, may be brought about through a specific disease process, just as bodily secretions are influenced alike by mental causes, and by the action of drugs. In normal life, these adjustments occur as reflex responses to the various situations that we meet, and the emotional state is given immediately in the bodily state ensuing

upon the response, because this itself constitutes the emotional state. In the psychosis, a certain adjustment is maintained through a pathological condition, and the world is seen through dark glasses.

The former condition results in the transitory depressions which many of us know only too well; the latter, in the fundamental depressions of the psychoses. The appearances which the two conditions present to ordinary observation are really very similar. The "feeling of inadequacy" is beyond question a concomitant of our own depressed moods, and the same must be said of retardation in so far as it is the direct offspring of inadequacy. The changes in speech and gait are especially illustrative in this respect. In sensitive and unstable individuals more serious manifestations may occur, as delusional interpretations of trivial occurrences, and the contemplation of suicide. But the basic difference between the two states remains, in that the former is the product of external, mental causes, and would disappear upon the removal of these causes,¹ while the latter is an internal organic manifestation that responds little, if at all, to mental influences, and disappears when the disease process ceases to be active. It is also true that there is less clouding in the normal depressions, but we must remember that the delusional content in the manic-depressive depressions is often secondary, and results from the delusional coloring, by the depression, of insignificant happenings, or through a feeble attempt to account for the existence of the depression. Moreover, the very group of psychoses in which confusion is the most prominent, and would have the best title to be assigned a fundamental value, are precisely the conditions in which *hallucinosi*s is also the most prominent, and this upon a specifically toxic history; namely, the acute exhaustion and the drug psychoses. Here the delusions may be largely secondary to the hallucinations. Altogether, no great stress can be laid on delusions as a primary symptom in manic-depressive insanity, and a considerable number of cases will fail of correct interpretation without the full recognition of the fundamental character of depression and the multiplicity of symptoms, including retardation, which can be secondary to it, as well in normal life, as in the psychoses.

The second group is not so easy to interpret from the standpoint of our normal reactions, but we are forced into making such a group on account of the great disproportion that often exists between the retardation and the depression. We cannot

¹As in Banquo's reply to Macduff on learning of the murder of Duncan,

"Dear Duff, I prithee, contradict thyself,
And say it is not so."

satisfactorily account for all phenomena of retardation on the basis of its being secondary to depression. Indeed, some points of view regard the retardation as the one fundamental quality, and the depression as secondary to it. It may be questioned, however, whether such a formula does not involve a conception of the term retardation more limited and specific than is yet justified in clinical knowledge. If an individual becomes depressed at finding himself primarily retarded, clearly the brain-processes which give the consciousness of the retardation do not share to any great extent in the retardation. It must be obvious that a fundamental and diffused retardation must in time result in a general dulling of mental faculties, in which the emotions share. This would give us ultimately a condition resembling apathy rather than depression, and is one that we not infrequently see. In its profounder manifestations, every trace of affective life may be completely engulfed in the retardation. Characteristic motor symptoms may ensue, such as negativism, stereotypes, catalepsy and the like, which often give the case an extremely *præcox*-like appearance. This, and not affective depression, is the logical result of a generalized retardation.¹ If the reader will pardon a somewhat loose employment of the adjective, a "peripheral" retardation is the normal psychomotor result of a depression (at least in younger individuals); but that a depression might be secondary to a retardation, the retardation, while it might involve some element of a pure thinking disorder, would usually be one involving only relatively low levels of psychomotor activity, a retardation *die sich im Rückenmark abspielt*, to borrow a phrase of Jung's.

But while maintaining the existence of retardations of the above general type and their special influence on the emotional tone, this specialized type of retardation may after all be the best conception of those cases in which the retardation appears to preserve an absolute independence of the affective life. It is very difficult to understand how a fundamental, generalized retardation could have for its affective result any other condi-

¹ Here, again, we have a not inept parallel in normal life. The fatigue following physical exertion is accompanied by a condition not dissimilar to retardation, in which the emotional life shares to a peculiar extent. If while we are in such a condition we are met by a situation of considerable affective value, be it of an elevating or depressing nature, it is quite noticeable that the affect is, under these conditions, considerably less than when we are fresh and unwearied. There is teleology in this, for the promptness, decision and general efficiency of the outward response to a situation tends to be inversely related to the affective power of the situation, and it is precisely in situations likely to arise under such circumstances that a relative efficiency of the reaction may be most urgently demanded.

tion than apathy, and if we are to consider retardation as *secondary* to all the affective states with which it is clinically associated, we shall indeed make of it a psychiatric *filis de vingt pères*. Kraepelin analyzes the mixed states into variations of three fundamental symptoms, associative retardation or thinking disorder (*Denkhemmung*), motor retardation (*Willenshemmung*), depression (*Verstimmung*), and their opposites. The mixed states are given us in the different combinations of these traits. Inasmuch as in the regular pictures of manic-depressive depression the three run a largely parallel course, the writer has employed the term *retardation* to cover both the first and second of these symptoms; but in the mixed states we have to keep them separate, as we see them occurring independently, and must assign to each a fundamental value. We may find a flight of ideas and either a motor excitement or retardation, combined with either an emotional exhilaration or a depression; we may find a slowness in thinking (thinking disorder) and either motor activity or retardation, combined with either emotional depression or exhilaration. In these states it is difficult to conceive of any one symptom being secondary to another, because they are all so independent of each other. A psychomotor retardation is not what we should expect in the presence of euphoria (manic stupor), and that it does so occur argues its fundamental quality; in like manner do the cases of difficulty in thinking (thinking disorder), emotional depression, but motor activity (*Depressive Erregung*), and those of flight of ideas, emotional exhilaration, but motor quiescence, argue a retardation in the motor sphere independent and distinct from the intellectual as well as the emotional activities. This is the retardation, "*die sich im Rückenmark abspielt.*"

In sum, the immediate relation between retardation and depression may be threefold. A fundamental depression may give rise to a secondary inadequacy or retardation; a fundamental retardation not involving the higher psychic centres may conceivably give rise to a secondary inadequacy and depression. Both symptoms may appear in their fundamental quality, each presenting its special picture independently of the presence and character of the other. The experimental criteria of retardation that have been adduced do not depend for their existence upon phenomena of consciousness; they are merely special aspects of what may be observed under conditions in which consciousness is experimentally out of the question, as in the decerebrate frog. Our conception of retardation must, therefore, be more objective than something exclusively secondary and dependent upon the mood; the entire phenomena of retardation are the most easily comprehensible from the physiological point of view.

5. SUMMARY AND CONCLUSION

The phenomena of retardation are here studied according as they affect the curve of continued work. The form of experiment is the "tapping test," each individual curve consisting of 30" continued tapping, evaluated according to the number of taps made in the successive 5" intervals of the entire 30" period. The alterations of the work curve that appear especially associated with retardation are evident not only in the decreased amount of work performed (found in the lowered average efficiency of the group studied) but also in the improvement of the work under conditions in which normal individuals would show a fatigue loss or no characteristic change (*reversal* and *transference*). Among the manic-depressive depressions distinct phenomena of retardation, shown mainly in *reversals*, appear in Case I; in Case II they are less prominent; in Case III they are absent. In Cases IV and V they are again quite characteristic, in Case VI less so. In Case VII they are again absent, but there is a trace of *transference*. Transference is especially prominent in Cases VIII, IX and X. Cases XI and XII show especially prominent phenomena of reversal; in Case XII they are the most clearly observed. It is not made out whether reversal and transference represent different types of retardation; they occur largely independently, but simultaneously in Cases X and XII. These results, representing as they do increased responsiveness to the warming up effects of continued effort, are paralleled in the observations of Hoch with the ergograph and Hutt with the addition test. The rate of tapping tends to increase with improvement in condition and to decrease with a drop in condition; but the phenomena of reversal and transference may be swallowed up in a very deep retardation, appear as the retardation becomes less profound, and finally disappear as the retardation itself disappears. Kraepelin builds the manic-depressive depression upon three fundamental symptoms of *Denkhemmung*, *Willenshemmung*, and *Verstimmung*. The term *retardation* includes the first two of these; but the present phenomena are presumably the product of *Willenshemmung* plus *Denkhemmung* or *Willenshemmung* alone. In certain cases *Willenshemmung* and *Denkhemmung* may be secondary to *Verstimmung*; and in other cases *Verstimmung* may be secondary to the other two. All three, however, may and probably do have a fundamental and independent existence, especially in the mixed states. The "feeling of inadequacy" is itself never fundamental, but always secondary to either retardation or depression; it forms a bridge between the two. Whatever its origin, the retardation measured in the present experiments is

to be regarded as the product of immediately physiological conditions.

That free use has been made of the hospital records and physicians' notes in the interpretation of the individual cases, is scarcely necessary to add. The writer is also under obligations to the physicians of Boston Insane Hospital, through whom access was obtained to Cases IX and X. Special acknowledgments are due to the writer's colleagues in the McLean Hospital, Dr. E. Stanley Abbott and Dr. Frederic H. Packard. Such clinical suggestiveness as these studies may possess is largely due to them.